CLAIMS:

1. An integrated reactor for producing fuel gas for a fuel cell, the integrated reactor comprising:

an waste gas oxidizer (WGO) assembly having an associated WGO chamber, an inlet, an outlet and a flow path for exothermic gases produced in the WGO chamber; and

an autothermal reactor (ATR) assembly located at least partially in the WGO chamber, the ATR assembly having an inlet means and an outlet means for process gases flowing therethrough and a catalyst bed intermediate the inlet and outlet means, at least part of the inlet means of the ATR assembly being located in the flow path of the WGO chamber.

2. An integrated reactor as claimed in claim 1 wherein the WGO assembly further comprises a water flow path, the water flow path being in or adjacent the WGO chamber so that hot gases produced in the WGO chamber provide thermal energy to water flowing through the water flow path.

3. An integrated reactor as claimed in claim 2 wherein the WGO assembly comprises an inner wall and an outer wall, the inner and outer walls defining an annular space, wherein the annular space constitutes the water flow path.

4. An integrated reactor as claimed in claim 3 wherein the annular space between the inner and outer walls of the WGO assembly has a water inlet near a lower end thereof and a water/steam outlet near an upper end thereof.

5. An integrated reactor as claimed in claim 2 wherein the water

flow path comprises a limpet coil about the WGO chamber.

6. An integrated reactor as claimed in claim 2 wherein the water flow path is comprised of an internal heat transfer coil located within the WGO chamber.

7. An integrated reactor as claimed in claim 1 wherein the inlet of the WGO assembly comprises a first connector pipe for the introduction of anode off-gas from a fuel cell, and a second connector pipe for introduction of cathode off-gas from a fuel cell.

8. An integrated reactor as claimed in claim 7 wherein the WGO assembly further comprises a mix chamber for mixing the anode off-gas and the cathode off-gas, and ignition means for initiating combustion within the WGO assembly.

9. An integrated reactor as claimed in claim 8 wherein the ignition means is selected from at least one of: a spark plug, a glow plug and an ignition source.

10. An integrated reactor as claimed in claim 8 wherein the WGO assembly further comprises a surface radiator associated with a combustion flame holder for radiating heat within the WGO chamber.

11. An integrated reactor as claimed in claim 1 wherein the ATR assembly is substantially wholly located within the WGO chamber.

12. An integrated reactor as claimed in claim 1 wherein the ATR assembly comprises an inner chamber containing the catalyst bed,

and an outer wall, the inner chamber and outer wall defining an annular space through which process gases flow toward the catalyst bed, the annular space receiving thermal energy from the hot gases produced in the WGO chamber.

13. An integrated reactor as claimed in claim 1 wherein the ATR assembly catalyst bed comprises a partial oxidation catalyst, and two sequentially arranged steam methane reformer catalysts downstream of the partial oxidation catalyst.

14. An integrated reactor as claimed in claim 1 wherein the ATR assembly has separate inlet means for air, fuel and water.

15. An integrated reactor as claimed in claim 14 wherein the inlet means for the water comprises heat exchange means whereby thermal energy for water within the water inlet means is received from the WGO chamber.

16. An integrated reactor as claimed in claim 14 wherein the separate inlet means for air, fuel and water are converged into a combined single inlet means, the single inlet means having heat exchange means whereby thermal energy from the WGO chamber is received within the single inlet means.

17. An integrated reactor as claimed in claim 1 further comprising a shift reactor and carbon monoxide polishing assembly downstream of the ATR assembly.

18. An integrated reactor as claimed in claim 17 further comprising a valve means downstream of the shift reactor and CO

polishing assembly for selectively directing reacted gases back to the WGO assembly or to the fuel cell.

19. An integrated reactor as claimed in claim 1 further comprising a valve means downstream of the ATR assembly for selectively directing reacted gases back to the WGO assembly or to the fuel cell.

20. An integrated reactor as claimed in claim 1 wherein the inlet means of the ATR assembly comprises a separate fuel inlet means, the separate fuel inlet means including heat exchange means so that thermal energy from the WGO assembly preheats fuel in the separate fuel inlet means.

21. An integrated reactor as claimed in claim 1 wherein the inlet means of the ATR assembly comprises a separate air inlet means, the separate air inlet means including a heat exchanger for receiving thermal energy from reacted process gases exiting the ATR assembly.

22. An integrated reactor as claimed in claim 1 further comprising conductive thermal transfer members to facilitate spread of thermal energy within the ATR assembly.

23. An integrated reactor as claimed in claim 22 wherein the conductive thermal transfer member comprises a heat pipe extending vertically through the catalyst bed.

24. An integrated reactor as claimed in claim 22 wherein the conductive thermal transfer member comprises a plurality of heat pipes transverse to an axis of process gas flow, and extend through

a wall of the ATR assembly.

25. An integrated reactor as claimed in claim 22 wherein the conductive thermal transfer member comprises a series of wedge-shape conductors in the catalyst bed.

26. An integrated reactor as claimed in claim 1 wherein the catalyst bed comprises a partial oxidation catalyst and a plurality of steam methane reforming catalysts, arranged in a substantially vertical stack, and deflector means within and adjacent the catalyst bed for moving the process gases in a spiral flow path to enhance heat exchange with the WGO gases.

27. A method of providing thermal energy to process gases in an autothermal reactor (ATR) assembly, the method comprising:

positioning an ATR assembly at least partially within a chamber of an waste gas oxidizer (WGO) assembly, the ATR assembly having an inlet means and an outlet means for process gases flowing therethrough;

combusting waste gas within the WGO chamber to produce heat; and

locating the inlet means of the ATR assembly within the chamber of the WGO assembly to facilitate heat transfer therebetween.

28. A method as claimed in claim 27 wherein the ATR assembly is positioned wholly within the chamber of the WGO assembly.

29. A method as claimed in claim 27, further comprising introducing the process gases separately as water, fuel and/or air,

and preheating either or all of the air, fuel and water separately prior to mixing thereof.

30. A method of controlling an integrated reactor having an autothermal reactor portion and a waste gas oxidizer portion, the method comprising:

independently controlling the air or oxidant to the ATR portion with regards to the fuel flow to the ATR;

independently controlling the water/steam to the ATR portion with regards to the fuel flow to the ATR;

increasing the air or oxidant flow rate to enhance the rapid transient characteristics of the ATR process or decreasing the air or oxidant flow rate to enhance the higher efficiency characteristics of the SMR process.

31. A method as claimed in claim 30 further comprising:

independently controlling the air or oxidant to the WGO portion with regards to the heating value of the waste gas stream;

decreasing the air or oxidant flow to the WGO combustor enhancing the preheat temperature of the process gases entering the ATR or increasing the air flow to the WGO to enhance the heat transfer to the SMR section of the ATR while decreasing the preheat temperature of the process gases.